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MASON & HANGER
SILAS MASON CO., INC.

PLAN FOR REMOVAL AND DISPOSAL

OF PCB CONTAMINATED

SOILS AND SEDIMENTS

AT

WAUKEGAN, ILLINOIS

PREPARED FOR:

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION V
CHICAGO, ILLINOIS

SEPTEMBER 1980
CONTRACT NO. 68-03-2647

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TABLE OF CONTENTS

SECTION	TITLE	PAGE NO.
	Title Sheet	i
	Table of Contents	ii
	List of Figures	iii
I.	BACKGROUND	1
II.	EXTENT OF CONTAMINATION	1
III.	EXCAVATION PLAN FOR THE NORTH DITCH	3
IV.	DREDGING PLAN FOR WAUKEGAN HARBOR	6
V.	TREATMENT PLAN FOR SETTLING AND DEWATERING OF HARBOR DREDGING	11
VI.	DISPOSAL	12
VII.	SUMMARY AND COSTS	14

PLAN FOR REMOVAL AND DISPOSAL
OF PCB CONTAMINATED
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LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
1	Extent of PCB Contamination	2
2	North Ditch Bypass (Phase I) and Slurry Wall (Phase II) Plan	4
3	Typical Section for Crescent Ditch	7
4	Typical Section for Oval Lagoon	8
5	Waukegan Harbor Dredging Operation	10
6	Settling and Dewatering of Waukegan Harbor Dredgings: Site Layout	13

I. BACKGROUND

Contamination with polychlorinated biphenyls (PCBs) of the sediments of the Waukegan Harbor and the soils of the North Ditch area north of Waukegan Harbor have been confirmed by the investigations of at least seven organizations. The PCBs were primarily discharged from the Johnson Motors Division plant in Waukegan, Illinois of the Outboard Marine Corporation. It has been learned that during the years 1959 to 1971, the company purchased some 9 million pounds of PCBs for use in its aluminum die cast machines, and may have allowed 900,000 pounds or more to be discharged to the harbor and ditch. Some of the PCBs have been and are being carried into Lake Michigan. The rest of the PCBs remained to contaminate the sediments and biota of the ditch and harbor. Because of these sites proximity to Lake Michigan and the potential for future contamination of the Lake, a study has been undertaken by Mason & Hanger-Silas Mason Co., Inc. to determine the extent of the contamination and to recommend methods for removal. Mason & Hanger is now midway through this study, and this report will summarize the findings and recommendations to date. (There is still substantial data now being analyzed, particularly from the North Ditch area, which could substantially affect the final recommendations of this study.)

II. EXTENT OF CONTAMINATION

Sampling and analysis of the Waukegan Harbor sediments indicate that the sediment is contaminated with polychlorinated biphenyls (PCB). The harbor bottom consists of three distinct layers; a 4-10 foot soft sediment or organic silt layer hereafter referred to as "muck" (40-50% moisture), a sand layer (10-20% moisture) and the natural clay harbor bottom. The following describes the extent of the contamination of each of these layers:

First, PCBs have been detected in the muck layer in all areas of the harbor with the highest concentrations occurring in Slip Number 3 (see Figure 1). Secondly, the data gathered thus far appears to indicate that PCBs are present in the sand layer in minute quantities (less than 10 parts per million (ppm)). Additional samples have been collected to indicate the extent of the contamination in the sand layer. Analyses are pending for these samples. However, Mason & Hanger now maintains that the sand layer is not highly contaminated. (The ground water table is above the sand layer which would indicate that water migration is into the lake instead of out of the lake. Thus, the harbor water does not migrate through the sand layer depositing PCBs on the particles of sand.) Thirdly, the concentration of PCBs in the clay layer is below 1 ppm. All references to concentration of PCB in this report are based on a dry weight basis.

Therefore, since the muck layer is the most highly contaminated and the one for which the most data and information are available, the following will describe the various sites and the extent of contamination in each:

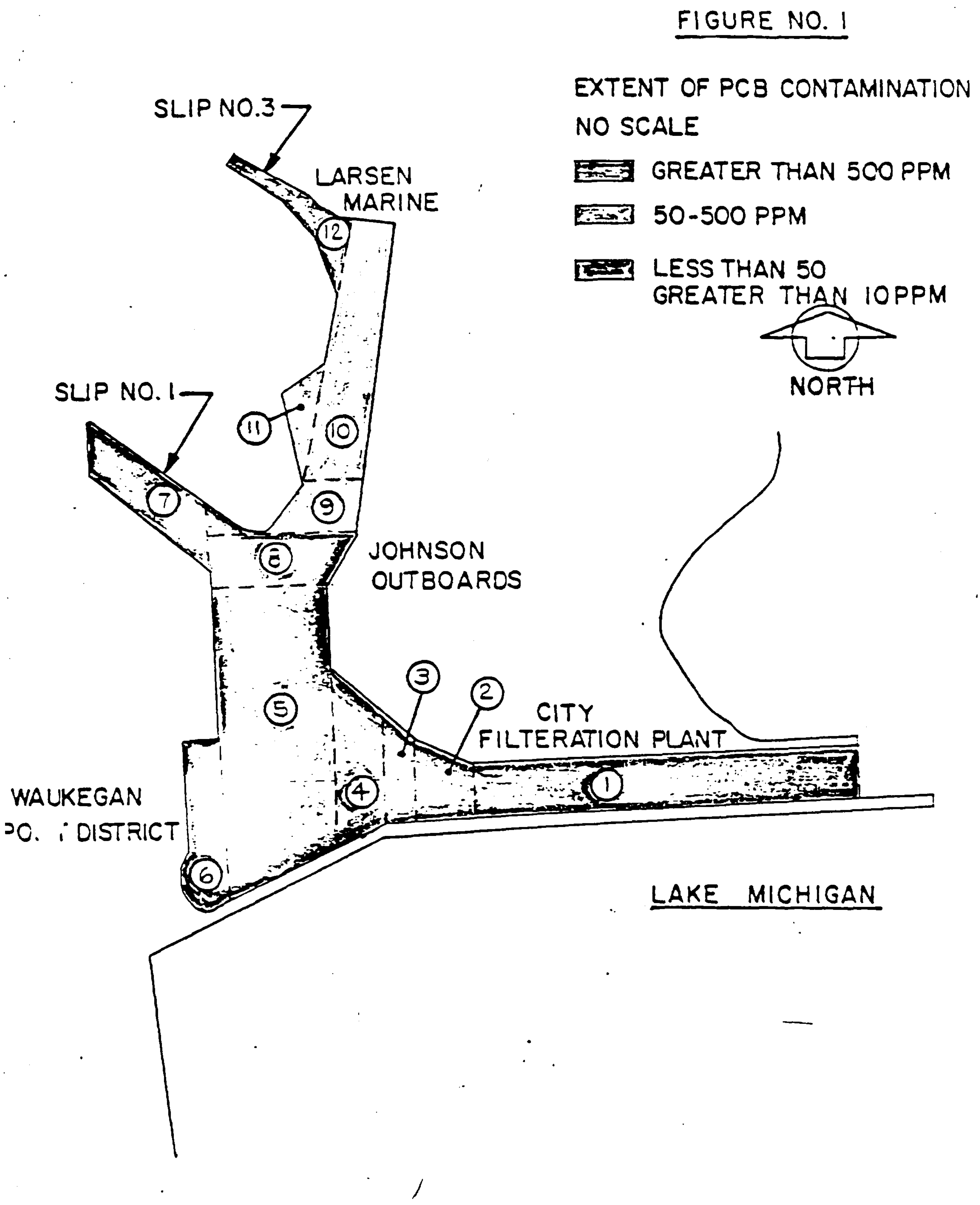


FIGURE NO. 1
EXTENT OF PCB CONTAMINATION
NO SCALE
GREATER THAN 500 PPM
50-500 PPM
LESS THAN 50
GREATER THAN 10PPM
NORTH
SLIP NO.3
LARSEN
MARINE
12
SLIP NO. 1
11
10
7
9
8
JOHNSON
OUTBOARDS
3
2
5
CITY
FILTERATION PLANT
4
1
WAUKEGAN
DISTRICT
6
LAKE MICHIGAN

A. Slip Number 3 is the most highly contaminated area. The muck layer in this area is approximately six feet deep, and PCB concentrations as high as 400,000 ppm (40% on a dry weight basis) have been detected here. Approximately 17,000 cubic yards of muck (in situ) would have to be removed from Slip Number 3 to reduce the contamination.

B. Between Slip No. 1 and Slip No. 3, Areas 9, 10 and 11 of the main channel (defined by Figure 1) have a muck layer approximately six feet deep which is contaminated with PCBs in a range of 50 to 500 ppm. The total volume of muck in these three areas that would have to be removed is 64,000 cubic yards (in situ).

C. PCB concentrations have been detected in the muck layer of the remaining areas of the harbor, including Slip No. 1, in the 10 to 50 ppm range. The volume of the muck in these areas (1 through 8) is approximately 142,000 cubic yards. The depth of the muck in these areas of the harbor varies from 1 to 2 feet in Areas 1 and 2 to 6 to 7 feet in Areas 8 and 9.

The quantity of muck that would have to be removed is dependent on the desired PCB concentration to remain in the harbor. To reduce the PCB concentration in the harbor to a level below 50 ppm, 81,000 cubic yards would have to be removed. In order to reduce the PCB concentration in the harbor to a level below 10 ppm, an additional 142,000 cubic yards of muck would have to be removed, for a total of 223,000 cubic yards. (Thus far, the present data indicates that none of the sand or clay layer would have to be removed.)

Some analyses have also been performed on some of the samples taken from the North Ditch. The results of these analyses indicate the bottom of the ditch is highly contaminated (some concentrations in tens of thousands ppm PCB) throughout its whole length, and in the area of the discharge the PCBs have permeated to depths of at least 25 feet (at this depth the results have shown concentrations of thousands of ppm PCB). Vertical dispersion of the PCBs has thus been proven, but the extent of lateral dispersion will not be known until further samples have been analyzed. Further sampling might also be required.

III. EXCAVATION PLAN FOR THE NORTH DITCH

The scheme now being investigated for removing the contaminated soils from the North Ditch is based upon performing the work in two phases. Phase I would involve the construction of a bypass around the crescent ditch and oval lagoon. The bypass would be constructed of large reinforced concrete pipe and would replace the E-W portion of the North Ditch up to a new headwall located near Lake Michigan. Work for Phase II would consist of building slurry walls around the areas bypassed in Phase I and excavating the contaminated materials contained therein. Figure 2 shows a plan view for the work involved in both phases.

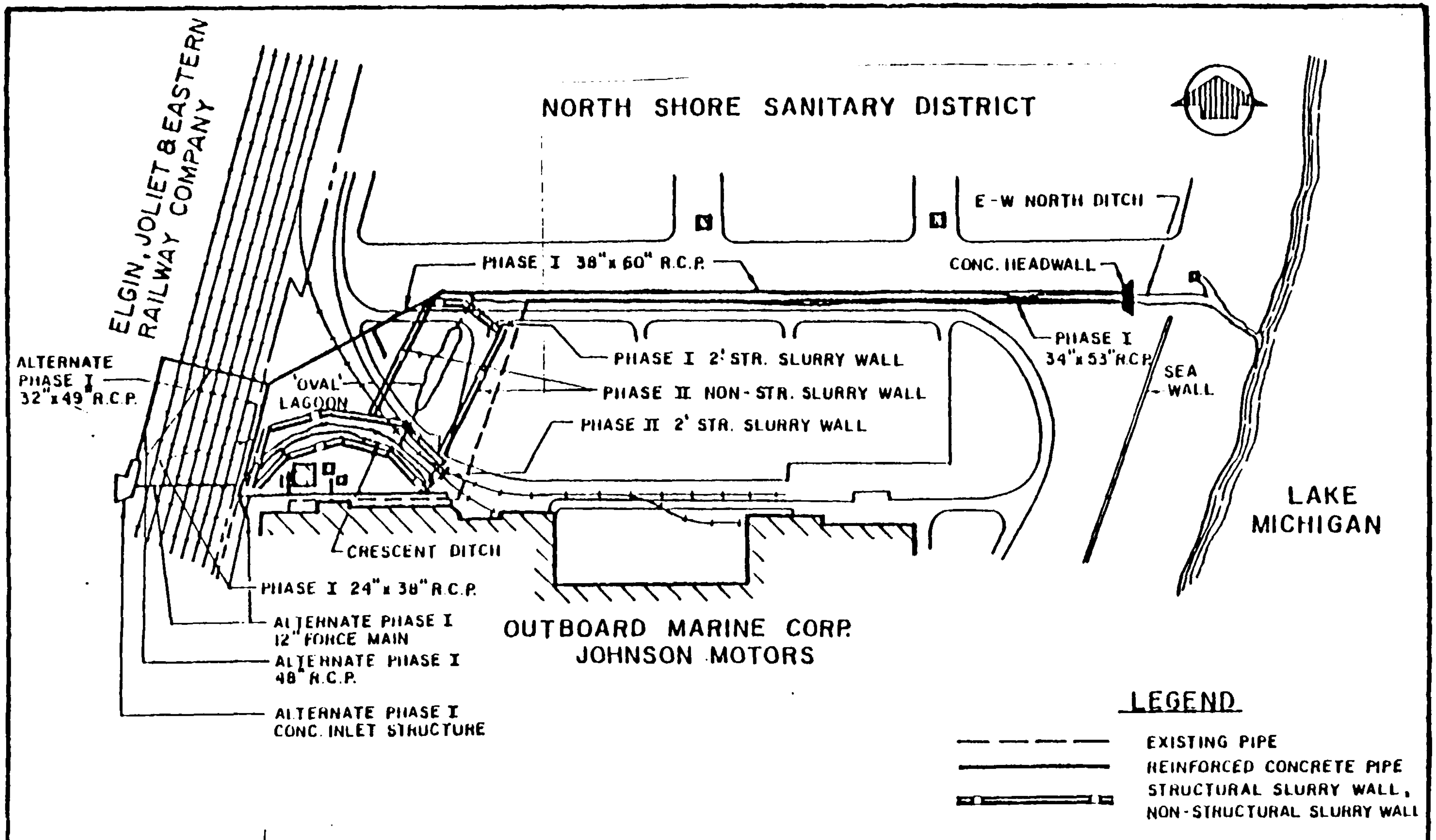


FIGURE 2: NORTH DITCH BYPASS (PHASE I) AND SLURRY WALL (PHASE II) PLAN

NO SCALE

Bypassing the most highly contaminated areas with the piping of Phase I will prevent surface water contamination now resulting from water flowing through those areas. As a result, only groundwater movement through the area, which is at a much lower rate than surface water, can become potentially contaminated. During construction of the Phase I bypass, the surface water will have to be pumped around the construction and into Lake Michigan. Also, there will be a need to locally lower the ground water table at the construction site. This will allow installation of the new piping and removal of the contaminated soils to be performed under dry conditions. The water thus removed will probably require treatment before discharge. Mason and Hanger is considering an alternative for the Phase I bypass. The Phase I basic plan calls for a 24 inch by 38 inch reinforced concrete pipe (RCP) to be located on the east side of the railroad tracks and be parallel to them. If the soil in this area is highly contaminated, then a force main will have to be constructed under the railroad tracks. When it reaches the other side of the tracks, the pipe will go north parallel to the tracks until it nears the northern boundary of the Outboard Marine Corporation's property. At this location, the pipe will again go under the railroad tracks and then go toward the head end of the E-W section of the North Ditch. From this point on, the pipe is located as discussed earlier.

The work involved in Phase I and Phase II can either be done concurrently or as separate entities. However, Phase II cannot be begun before a bypass is operational to carry the waters around it. (Before any exact description of the extent of the cleanup in the areas excavated under Phase II can be established it will first be necessary to identify the extent of the contamination. An accurate description of the contamination will probably require some additional sampling in the crescent ditch and oval lagoon areas, pending the results from the analyses now being performed.) Phase I can be completed and fully operational before Phase II is begun, with a period of years even separating the work involved in the two phases. The following presents a description of the work involved in Phase II.

For Phase II, regardless of how the contamination has spread laterally, there are certain restraints that govern the practical limits of excavation of contaminated materials. These are the structures on the south side of the crescent ditch. In this location there are several buildings and a water tower and not too far away is the main OMC building. If the contamination levels under the building are higher than the allowable level, then a decision will have to be made to excavate under the buildings or not excavate. Since excavation under the buildings could disrupt OMC's operations, consideration would have to be made of the extent of potential damages to the Company as opposed to the future effects of leaving the material in situ. (For the purposes of this report, it has been assumed the levels of contamination under the buildings are at an acceptable low level and the extent of contamination to include only that area which can be excavated without disruption or damage to any buildings.)

A study to determine the practical limits of excavation on the south side of the crescent ditch has resulted in a plan which would allow excavation to possibly 30 feet horizontally to either side of the ditch. It would allow excavation to a depth of about 25 feet if necessary. The plan is to build a slurry wall that can be braced from side to side for lateral stability. Figure 3 depicts this type of slurry wall arrangement. The slurry wall would be as close to the existing structures, on the south side of the ditch, as is practical so as not to disturb the structures.

A slurry wall enclosure is necessary because excavation of the contaminated materials must be done in a dewatered condition so that the limits of contamination can be measured during excavation. To do this, it is necessary to dewater the area inside the slurry wall. When this is done, it is mandatory that there be no significant leakage of water through the slurry wall that will significantly lower the water table outside the excavation area. If the water table outside the excavation area is lowered, it could cause settlements of structures which could be very detrimental. Thus, the slurry wall must be deep enough into the "clay" layer, which is about 25 feet below surface, to prevent any significant leakage below the bottom elevation of the slurry wall. Since this type cutoff wall must be deep enough to go into the clay layer and must be completely continuous at its perimeter, it may be necessary to relocate certain structures currently within the proposed excavation area. These are sanitary sewers and storm sewers which can be relocated and perform the same function they are now performing. One other precaution that may be required is the underpinning of the existing water tank, because this type structure is highly susceptible to damage from even slight movements. After the excavation of the contaminated material is completed, the slurry wall would be cutoff just below grade and left in place.

The foregoing discussion has been limited to the crescent ditch portion of the North Ditch. A similar plan could be used for the oval lagoon portion. However, there are no structures close enough to the sides of the lagoon that would limit the width of the area to be excavated. The slurry walls very likely may be placed far enough from the sides of the lagoon that they do not require bracing. Figure 4 shows the anticipated arrangement.

In summary, Phase I consists of a reinforced concrete pipe bypassing the crescent ditch and oval lagoon portion of the North Ditch, and replacing the existing E-W portion of the North Ditch. The surface water from the areas upstream of the North Ditch will be intercepted and directed around the contaminated areas through the bypass to Lake Michigan. Phase II will be the construction of slurry walls around the crescent ditch and oval lagoon, and the excavation and disposal of the contaminated materials contained within the boundaries of the slurry wall.

IV. DREDGING PLAN FOR WAUKEGAN HARBOR

Thus far, the results of the extent of contamination analysis indicate that only the organic silt "muck" layer requires removal. There are several harbor samples still requiring analysis which could potentially

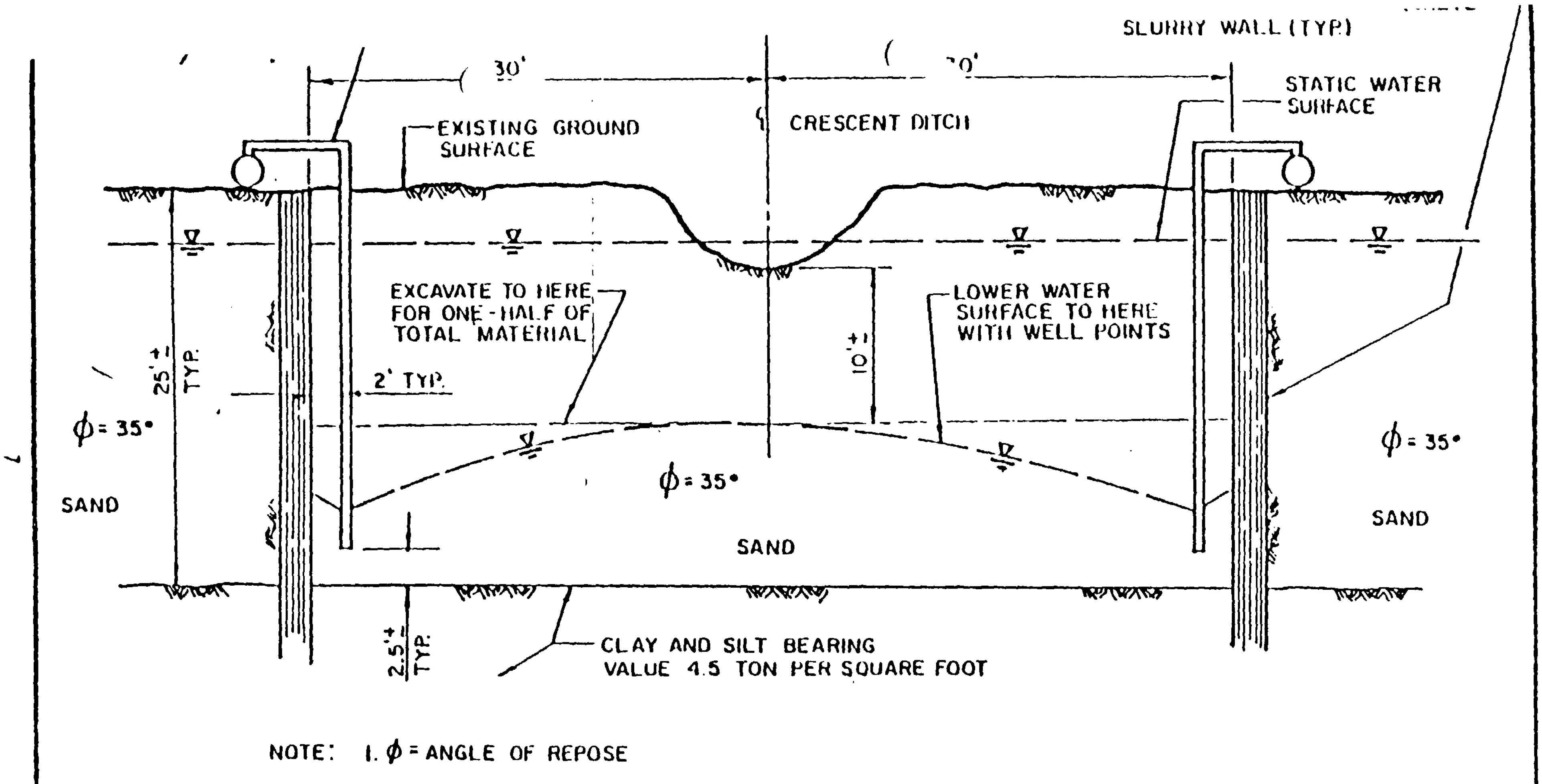
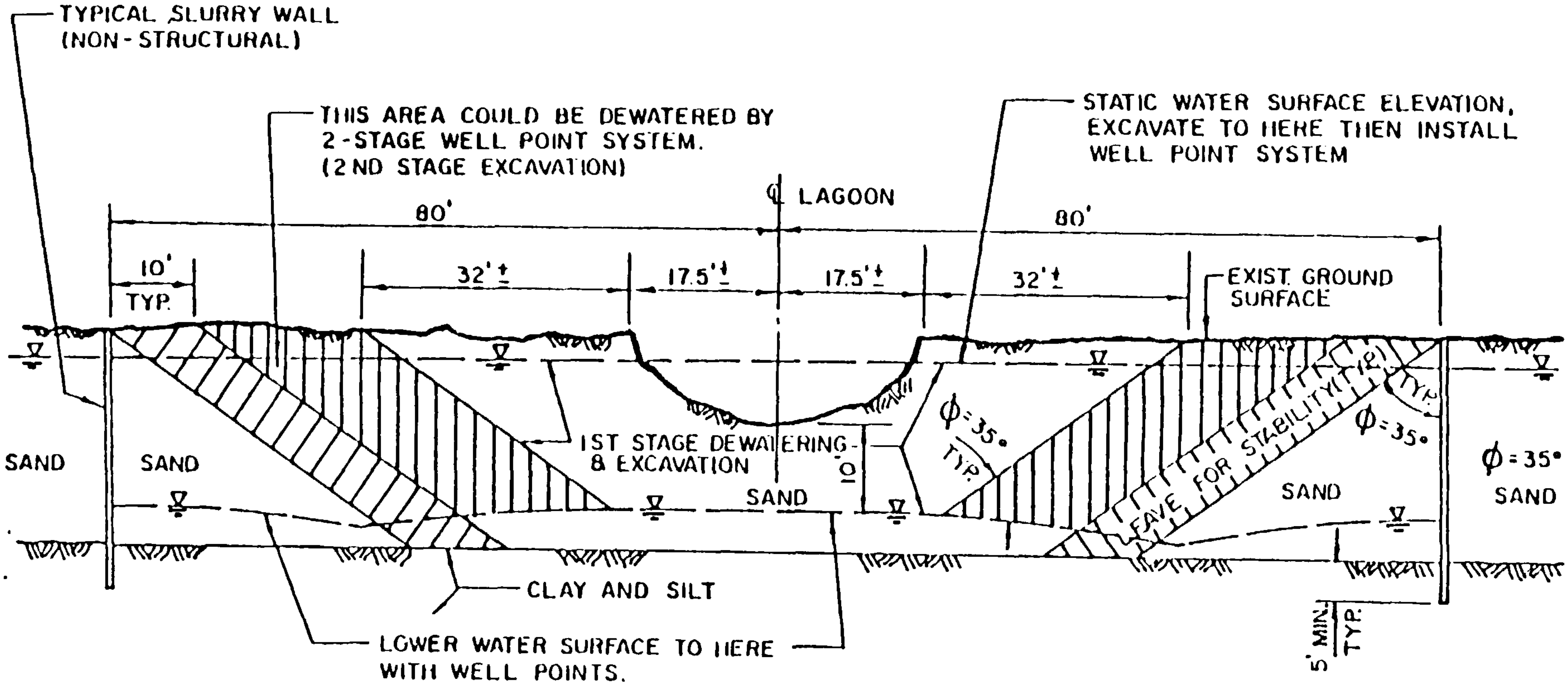


FIGURE 3: TYPICAL SECTION FOR CRESCENT DITCH

SCALE: 1" = 10'



NOTE: 1. ESTIMATED WEIGHT OF WET SAND IS 120 POUNDS PER SQUARE FOOT.
2. ϕ = ANGLE OF REPOSE.

FIGURE 4: TYPICAL SECTION FOR OVAL LAGOON

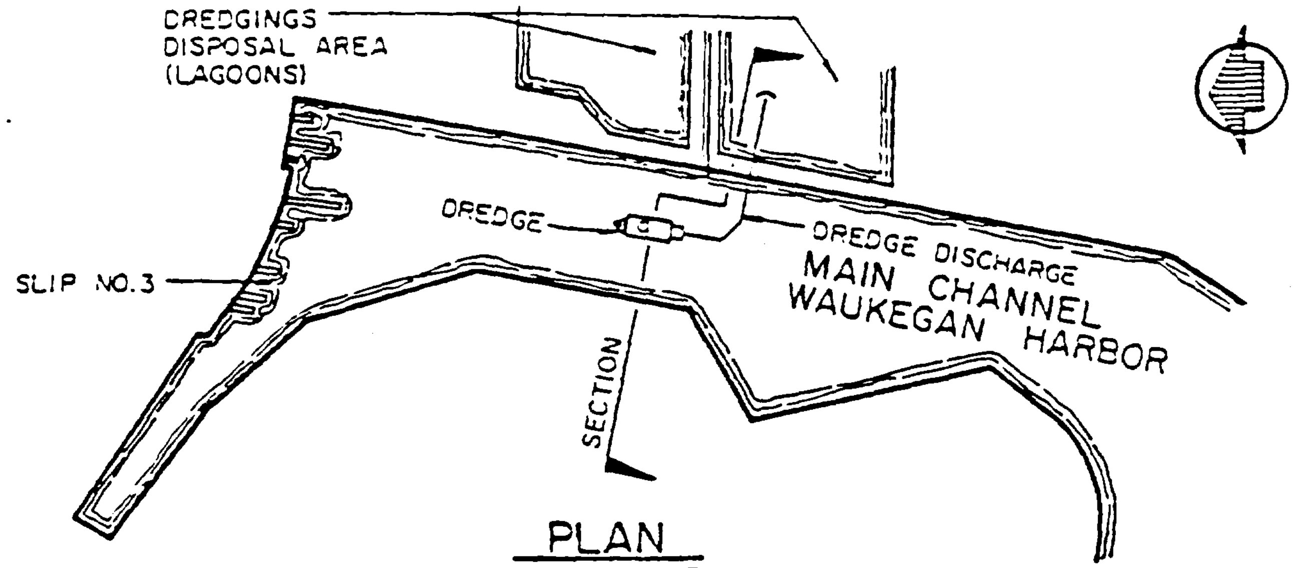
SCALE: 1" = 20'

change this conclusion, but at this time the dredging plan is based only on removal of the "muck" layer. The plan is based on removal of the complete "muck" layer, down to sand, primarily because the results of the previous studies do not show distinct layers of contamination in the material. To remove all of the material which potentially contains greater than 50 parts per million PCB will require the removal of all of the "muck" from and including Slip No. 3 to Slip No. 1, as indicated on Figure 1. To remove all of the material which potentially contains greater than 10 parts per million PCB will require the removal of all of the "muck" in the Harbor. The associated volumes, as stated previously in Section II, Extent of Contamination, are 81,000 cubic yards of materials contaminated to greater than 50 parts per million PCB and 223,000 cubic yards of materials contaminated to greater than 10 parts per million PCB.

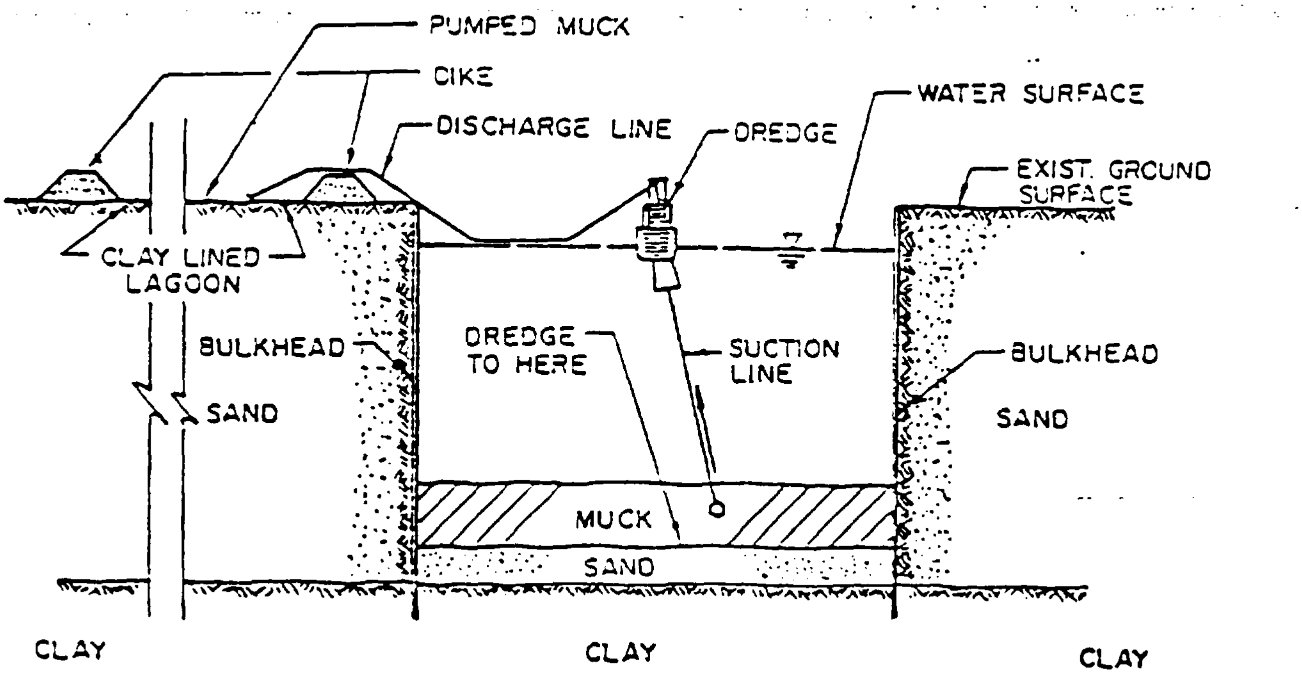
The basic properties of the "muck" (namely, a high moisture content, a soft black organic clayey silt with a trace to some sand, and an inability to support a load, as indicated by zero blow counts when it is tested for soil properties) make it a suitable candidate for dredging with a hydraulic dredge. Another important consideration in the selection of the dredge is the depth to which it must work. Even in the upper parts of the harbor, where the contamination is greater than 50 parts per million PCB, there are depths from the water surface of at least 25 feet to the bottom of the "muck" layer. To accomplish dredging to this depth, the dredge should be capable of dredging to depths up to 28 feet, as water level fluctuations may require this greater depth.

The proposed plan for dredging is to begin operations in Slip No. 3. This would allow the most highly contaminated materials to be removed first, and should provide for the highest degree of capture of any materials which would be suspended during dredging. Depending upon the dredge finally selected for the work, there is a good probability that the operations will be conducted within the confines of a silt screen. The silt screen would contain most of the sediments stirred up by dredging within a confined area, and after settling they would still be contained within this area. The work would then proceed along the west side of the Harbor. After several trips through this area, navigation could be resumed in this section while dredging continues toward the east side.

One type of hydraulic dredge which is suitable for this work has a suction pipe with a flanged head. The pipe is normally at a 45 degree angle with the water surface, and would be inserted into the "muck" near the sand. With this type of operation, the upper layers of the "muck" would actually act to lessen the suspension of any sediments caused by the dredging. This plan recommends the inclusion of a silt screen as part of the equipment provided by the dredging contractor; however, it would only be used if observations of the initial operations indicated it was needed. After the sediments have been removed from the harbor



PLAN
NO SCALE



SECTION
NO SCALE

FIGURE 5: WAUKEGAN HARBOR DREDGING OPERATION
NO SCALE

bottom, they are pumped through piping which floats on the harbor water surface to a new treatment plant (discussed in the following section), which would settle solids and remove PCBs from the water to be discharged back to the harbor or Lake. Figure 5 shows how a hydraulic dredge would operate.

There are several other considerations important to the successful operation of a hydraulic dredge. Dredges of this type are typically maneuvered by using spuds and anchors. Spuds are long steel structural members which are dropped into the sand underlying the "muck", thus anchoring the dredge into place. There is potential that some sediments may be stirred up during this process. Again, it is recommended the operation be observed, and, if then deemed necessary, a silt curtain be used to contain these sediments. This plan recommends the dredge also be equipped with a cutter head, as this might be necessary to ensure removal of all of the "muck".

V. TREATMENT PLAN FOR SETTLING AND DEWATERING OF HARBOR DREDGINGS

The proposed treatment is based on removing 81,000 cubic yards of "muck" containing over 50 parts per million (dry weight basis) of PCB plus another 142,000 cubic yards of "muck" containing between 10 and 50 parts per million of PCB.

Physical tests on these sediments taken at six harbor locations showed the specific gravity varies from 1.3 to 1.7 and percent water to vary from 22 to 62. Typically, 70 or 75 percent of these sediments when slurried with water will pass through a 200 mesh screen indicating the typical particle size is very small. Laboratory tests showed that the sediments are very difficult to settle and dewater. The sediments when slurried with water and allowed to settle still contained several hundred parts per million suspended solids in the water phase; these suspended solids were so fine (colloidal) that they passed through a laboratory sand filter (2 foot depth, flow rate 3 gallons per minute per square foot). A primary coagulant (such as alum or cationic polymer) was found to be necessary to settle these fines before filtration.

The proposed treatment plan involves the following steps:

A. The Waukegan Harbor dredgings are pumped to a large settling lagoon. Separate lagoons are to be provided for PCB over 50 ppm and PCB between 10 and 50 ppm if all PCBs greater than 10 ppm are to be removed.

B. The dredging solids are allowed to settle in the lagoon.

C. The water level in the lagoon is controlled by a weir at one end; the water overflows the weir into a sedimentation basin for settling fines. A primary coagulant is added at the weir location.

D. The water is pumped from the sedimentation basin to a pressure sand filter followed by a carbon filter.

E. The carbon filter effluent flows by gravity back to the harbor. Simulated laboratory tests demonstrated that the PCB content of the water returned to the harbor should be less than one part per billion.

F. When the lagoon fills with solids, excess water is drained (routing through the filters) and the dredgings will be transported to a landfill.

A possible treatment site layout is illustrated by Figure 6. If operations are carried out during winter, a temporary building will be required to house the filters and polymer feed equipment.

VI. DISPOSAL

After the highly (greater than 50 parts per million (ppm) PCB)) contaminated materials have been excavated or dredged, they will require disposal to a chemical waste landfill. At the present time, the nearest licensed landfill to Waukegan to receive PCB contaminated wastes is CECOS in Williamsburg, Ohio. Several local sites are being investigated in addition to CECOS, as it may be possible to upgrade or change their classification so they may receive the PCB contaminated wastes. Most of the sites under consideration will require having the wastes trucked to them. These trucks will have to be modified so as to prevent leakage of any contaminated water or sediments during the trip to the landfill.

The landfill to which the wastes are to be taken will have to be in compliance with the latest federal regulations governing the disposal of hazardous wastes. A properly operated and constructed landfill will have its bottom and sides made of an impermeable layer. To ensure the impermeable layer is functioning properly, there will be monitoring wells all around the site which can be checked to ensure the groundwater is not contaminated. The cover over the top of the wastes after they have been landfilled will also have to be impermeable to prevent surface runoff or rainfall from coming into contact with the wastes. The operator of the site will also have to post a bond which will ensure the site will be monitored for many years in the future.

The sediments from the harbor will probably be divided into two classes, one being under 50 ppm PCB and the other greater than 50 ppm PCB. The present federal guidelines allow materials contaminated below 50 ppm to be disposed in a properly operated sanitary landfill, while those above 50 ppm must be taken to a chemical waste landfill.

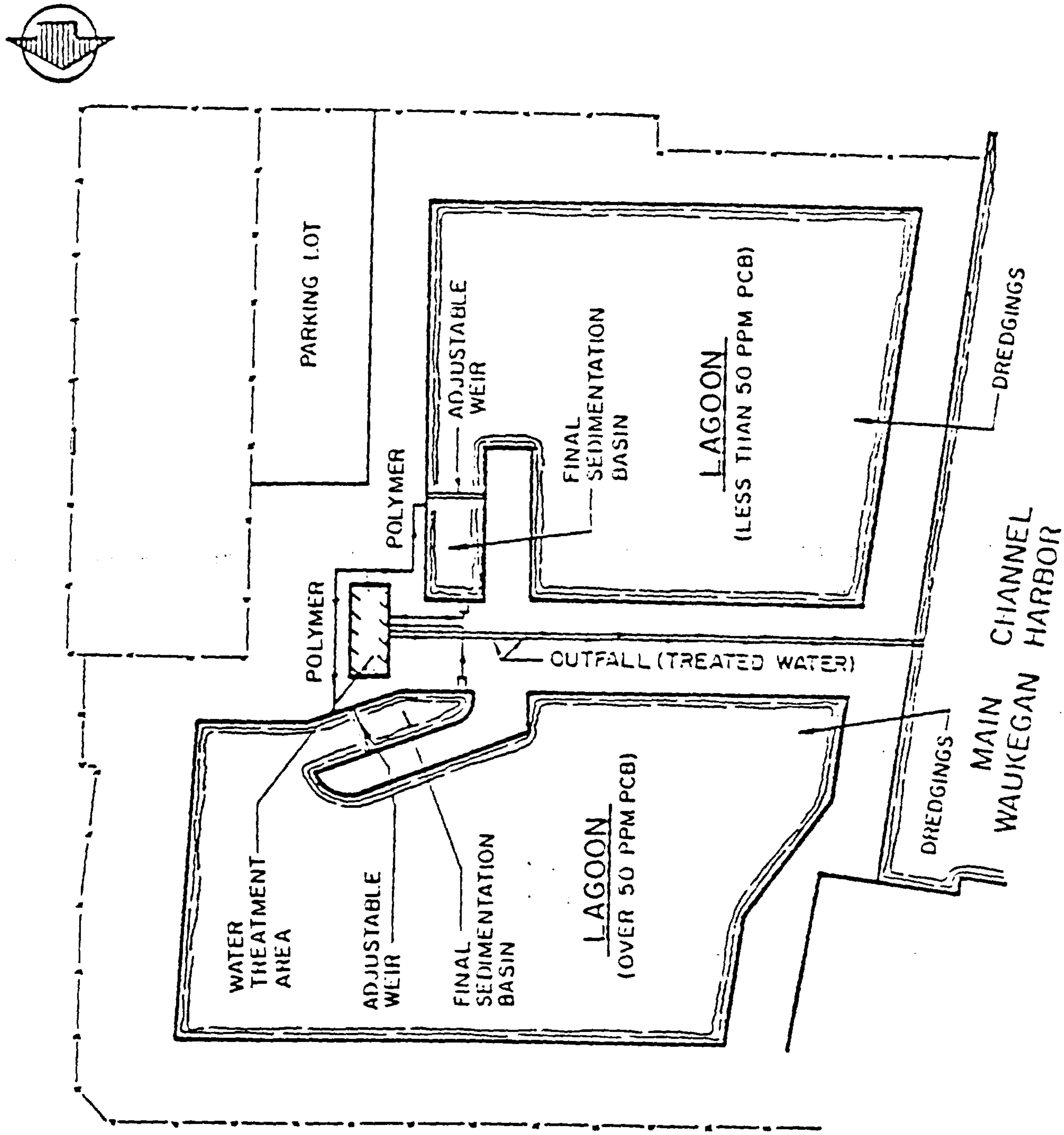


FIGURE 6: SETTLING AND DEWATERING OF WAUKEGAN HARBOR DREDGINGS: SITE LAYOUT

SCALE: 1" = 200'

VII. SUMMARY AND COSTS

The preceding report has discussed several phases and scopes of work involving the removal of contaminated sediments and soils from the North Ditch and Waukegan Harbor. The costs associated with each are outlined in the discussion below. The costs for the North Ditch work are most subject to change (as there is a considerable number of samples still requiring analysis to delineate the extent of contamination in that area).

In summary, the Phase I Base Plan calls for building a reinforced concrete pipeline around the highly contaminated crescent ditch and oval lagoon areas of the North Ditch. In this plan the construction costs include the expense of hauling the contaminated soils excavated from the E-W portion of the North Ditch to a chemical waste landfill located within ten miles of the site. The Phase I Base Plan (Alternate) includes the additional expense of laying a force main under the railroad tracks and then coming back under the tracks at a more northerly location and tying into the remainder of the Phase I Base Plan. This would only be done if the soils in the westernmost portion of the crescent ditch are highly contaminated.

Phase II (Maximum) includes the costs associated with the construction of slurry walls around both the crescent ditch and oval lagoon portions of the North Ditch. The costs include monies for withdrawing and treating the water from inside the slurry wall, and excavation of most of the soils within the limits of the slurry wall for the crescent ditch. Phase II (Minimum) is the same as Phase II (Maximum), except only half of the soils excavated in Phase I (Maximum) are removed from the crescent ditch. Both include removing the same quantity of materials from the oval lagoon (corresponding to a sloped excavation to a maximum depth of 10 feet below the bottom of the lagoon) and hauling the material to a chemical waste landfill located within ten miles of the site.

The dredging costs associated with the scopes of work in Waukegan Harbor include the setup, operation and discharge of the dredged sediments by a hydraulic dredge to the settling lagoons of the treatment system. The dredging costs are based on 8 hours per day, 5 days per week of actual dredging in the summertime, with 200 cubic yards (in situ) being removed per hour.

Settling and dewatering costs are based on removal and settling of 200 cubic yards of harbor muck per hour, and treatment by sand and carbon filtration of 2,000 gallons per minute of spent water (used to slurry the harbor muck sediments plus storm water) for PCB removal before returning to Waukegan Harbor. The lagoon will have an impervious clay liner.

The costs of hauling of dredge spoils after treatment are based on their being taken to a chemical waste landfill located within ten miles of the site.

Outlined below are the costs (based on 1980 dollars) associated with the work as discussed above:

Disposal not included

North Ditch:

Scope of Work	Contaminated Mat'ls Removed (cubic yards)	Costs of Construction & Operation
Phase I Base Plan	6,900	$ 2,300,000
Phase I Base Plan (Alternate)	6,900	2,500,000
Phase II Plan (Maximum)	41,900	4,600,000
Phase II Plan (Minimum)	27,500	4,100,000

Waukegan Harbor:

Scope of Work	Contaminated Mat'ls Removed (cubic yards)	Costs of Construction & Operation
Dredging (greater than 50 ppm)	81,000	$ 640,000
Settling and Dewatering of Harbor Dredgings	81,000	1,020,000
Hauling of Dredge Spoils after Treatment	78,000	620,000
Dredging (greater than 10 ppm)	223,000	1,610,000
Settling and Dewatering of Harbor Dredgings	223,000	1,720,000
Hauling of Dredge Spoils after Treatment	215,000	1,710,000

In conclusion, several important factors must be considered in an evaluation of the work required to "cleanup" the contamination in the North Ditch and Waukegan Harbor. First, it is important to recognize the costs proposed herein are based on 1980 dollars and will probably be considerably higher when the work is actually performed. Second, this study is still in a preliminary stage, with a considerable amount of data yet to be reported, so the costs as reported herein are subject to further modification. Third, disposal costs of placing the contaminated materials in a chemical waste landfill are not included, with this being a potentially major expense (particularly if the wastes must be trucked to the CECOS site in Ohio). Fourth, the process of obtaining permits and approvals may potentially cause substantial delays in the initiation of the project if a decision is made to proceed. Fifth, costs for engineering design, further laboratory analyses and sample acquisition, and preparation of permits are not included.

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